Low Dose, Risk, Decisions, & Risk Communication

Risk Communication, Fugitive Values, and the Problem of Tradeoffs at Rocky Flats

A REPORT

prepared by

Theresa Satterfield and Josh Levin
Decision Research
1201 Oak Street
Eugene, Oregon 97401

for the

U. S. Department of Energy
Low Dose Radiation Research Program

DECISION RESEARCH

Abstract

This report examines the processes of risk communication and public involvement in decisions about contamination and cleanup at Rocky Flats Environment Technology Site. It finds that risk- and science-communication efforts at Rocky Flats have been successful to the extent that much of the 'involved' public has achieved an impressive level of technical sophistication. However, this demonstrated scientific literacy did not lead to diminished conflict about the risks posed by residual contaminants at the site. Instead, improved public understanding of the risk estimates and the attributes of radiation hazards appeared coterminous with increased conflict and a crisis in confidence in public process. Our analysis finds that the periods of concentrated conflict, stress, and intermittent paralysis of public process at Rocky Flats were produced by the difficulty regulatory agents, the contractor, and the involved public all have managing the tradeoffs intrinsic to the cleanup. Public values, ethical concerns and objectives were not well organized or articulated in reference to key technical decisions. Consequently, the values central to the tradeoff dilemma had to masquerade as points about the scientific defensibility of different cleanup options. This in turn produced two central outcomes: First, the sublimated values (herein referred to as "fugitive" values) fostered a competitive (and sometimes detrimental) exploitation by all parties of technical expertise; second, the opportunity for democratic public involvement was eroded by, ironically, the success of risk-communication efforts as this lead to the reconstitution of public groups as each new group tried anew to realize agreement about cleanup decisions. We suspect that this pattern is not unique to Rocky Flats and thus propose a model for testing at other sites. The model explains the dynamics of risk communication and public-involvement processes as they pertain to low-dose radiation and possibly other hazards.

1. Introduction

The goal of this report is to examine the processes of risk communication and public involvement in decisions about contamination and cleanup at Rocky Flats Environment Technology Site. It begins with a brief history of the site, including significant production and post-production events, a discussion of methods, and a brief sketch of the public groups closely involved with cleanup of the site. Thereafter it examines the influence of the science of radiation hazards as well as budget and timeline constraints on public perceptions of risk and public involvement in cleanup. We focus on the way in which those involved in decisions at Rocky Flats both reflected and contradicted what is known about public perceptions of risk. We consider how knowledge about radiation risks played out in public-participation fora aimed at making decisions about the management of present and future risks at Rocky Flats. Finally, particular attention is paid to the problem of making difficult tradeoffs about the cleanup of Rocky Flats and the consequences of that difficulty for public participation itself.

The central thesis is that while 'risk-communication' efforts at Rocky Flats have been successful to the extent that much of the 'involved' public has achieved an impressive level of technical sophistication, this demonstrated scientific literacy did not lead to diminished conflict about the risks posed by residual contaminants at the site. Instead, improved public understanding of the risk estimates and radiation hazards appeared coterminous with increased conflict and a crisis in confidence in public process. Our analysis finds that the periods of concentrated conflict, stress, and intermittent paralysis of public process at Rocky Flats were produced by the difficulty regulatory agents, the contractor, and the involved public all have in thinking about the tradeoffs intrinsic to the cleanup. Tradeoffs are difficult because they are linked to value positions and because most cleanup efforts are constrained by time and cost. Consequently, achieving one objective or valued goal comes at the cost of giving up something else of importance (e.g., deciding whether to base soil cleanup levels on protecting the health of the most vulnerable citizens at additional costs versus protecting the health of the expected average citizen so as to realize cleanup gains elsewhere). Yet rather than developing the tradeoffs so as to render explicit the values or objectives of different participants, public discussion

fell into the default position of trying to increase scientific literacy to produce a more rational debate unencumbered by value disagreement. As a result, discussion became paralyzed by the sublimated value issues because the very values central to the tradeoff dilemma had to masquerade as scientific points about different cleanup options. This in turn produced two central outcomes: First, the sublimated values (herein referred to as "fugitive" values) fostered a competitive (and sometimes detrimental) exploitation by all parties of technical expertise; second, the opportunity for democratic public involvement was eroded by, ironically, the success of scientific risk-communication efforts as this lead to the reconstitution of public groups each increasingly specialized and aimed anew at realizing agreement about cleanup decisions. We suspect that this pattern is not unique to Rocky Flats and thus propose a model for testing at other sites. The model explains the dynamics of risk communication and public-involvement processes as they pertain to low-dose radiation and possibly other hazards.

1.1 Methods

The central aim of this report is to better understand emerging processes of risk communication about low-dose radiation exposure at Rocky Flats. Rocky Flats is one of many facilities within the U. S. Department of Energy's complex of nuclear arsenal production sites. The site is now permanently closed and is currently being remediated in order to return it to publicly useable space. Risk-communication practices at the site are currently concerned with low-level radiation in that the bulk of highly contaminated materials (e.g., concentrated volumes of plutonium) have or are being removed. Most attention is thus focused on the potential extent of residual low-level contamination in the site's soil and water once cleanup is complete.

Rocky Flats is an ideal site for case study purposes for those interested in the intersection of risk communication and concentrated public involvement in risk remediation programs. An extensive group of individuals and stakeholders makes up what is referred to locally as "the involved public." [More colloquially, the term is "Rocky Flats junkies."] These are the staff, individual citizens, and activists affiliated with the Citizen's Advisory Board; representatives (elected and not) of surrounding municipal governments (organized as RFCLOG or the Rocky Flats Council of Local

Governments); as well as a number of communication and coordinator specialists operating on behalf of the cleanup contractor (Kaiser-Hill), the U. S. Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Education (CDPHE). Each of these groups plays an integral role in ongoing local deliberations about cleanup at the site, although the nature of that role and the importance of different groups has varied (a phenomena we explain herein). Other, less formally constituted groups were also significant actors in the public-participation/risk-communication network such as the Rocky Flat Cleanup Agreement Focus Group (or RFCA Focus Group), the RSAL Working Group, including the Decontamination and Decommissioning Working Group (D & D), the Stewardship Working Group, and the Rocky Flats History Project. Each of these groups is comprised of differing combinations of private citizens, members of the CAB, RFCLOG, and staff scientists along with representatives from DOE and EPA. (A list of abbreviations is included as Appendix A.)

1.2 Data Collection

Data collection involved two primary methods: field observations and interviews with members of the "involved public." The specific interviewees and their group affiliations are listed below. Field observations involved attendance at ongoing group meetings and a tour of Rocky Flats. Between February and August 2001 one and occasionally both of the report's authors attended a total of approximately 15 stakeholder meetings. In any one week, there were and are still several possible meetings to attend. Only the Citizen Advisory Board meetings were routinely held in the evening and scheduled monthly; other groups often met weekly or bi-weekly. These primary sources of information were augmented by reviews of the Annual Reports and monthly bulletins published by the CAB, report documents produced by the different technical working groups, and media coverage of specific events. We are indebted to Len Ackland (1999) *Making a Real Killing* for considerable historical and background information.

RFCLOG: Rocky Flats Council of Governments

- Staff (*n* = 2)
  - Broomfield (*n* = 2)
  - Arvada (*n* = 2)
  - Westminster (*n* = 2)
- City government

CAB: Citizen Advisory Board

- Professional background: Science and/or engineering
  - Industry (*n* = 3)
  - College/University (*n* = 2)
- Professional background: Nonscience (*n* = 2)
- CAB staff (*n* = 3)
- Activist (*n* = 4)
- Other CAB members (*n* = 2)

REGULATORS AND CONTRACTORS (*n* = 6)

- DOE (*n* = 1)
- U. S. Environmental Protection Agency (*n* = 1)
- Colorado Department of Public Health and Education (*n* = 2)
- Kaiser Hill representatives (*n* = 2)

ACTIVE PUBLIC (non-CAB; *n* = 4)

- Activist (*n* = 3)
- Nonactivist (*n* = 1)

Local journalists (*n* = 3)

- *Rocky Mountain News,* Denver (*n* = 1)
- *Denver Post* (*n* = 1)
- *The Daily Camera,* Boulder (*n* = 1)

RELATED DISCUSSION GROUPS:

Specialist:
[comprised mainly of staff scientists]

- Decommissioning and decontamination working group
- RSAL working group (attended by mostly scientifically literate CAB members)

Multi-stakeholder groups:
[comprised mainly of members of the CAB, RFCLOG, and Kaiser-Hill representatives]

- RFCA focus group
- Stewardship working group
- RF history project

***N* = 35**

Interview Sample. A total of 35 ethnographic interviews were conducted by occasionally one and mostly both of the report's authors. These were conducted over a period of 9 months, from November 2000 through July 2001; the majority were conducted between April and July 2002 during one-week episodes of concentrated interviewing in each of the four successive months. The names of interviewees are not revealed for the sake of anonymity. The specific number and the group affiliation of interviewees is detailed in Figure 1 as are the names of linked hybrid 'spin-off' groups. You will note that we sought representation from all groups, but focused much of our attention on members of the CAB and RFCLOG (many of whom were also active participants in the Rocky Flats Focus Group). Reporters from local newspapers were interviewed to gain a sense of the patterns of coverage and public interest over time and to collect information about key events at the site in the recent period.

Interview Schedule. All interviews were open-ended. In each case our primary interest in risk communication and public involvement in decision making at Rocky Flats was stated at the outset. Each interview followed its own internal topical arc but in each case we were nonetheless careful to cover the following areas of interest, sometimes directly, sometimes less so:

- perceptions of low-dose radiation risks and health consequences
- discussion of radiation safety standards and their application at Rocky Flats
- observations about the constitution and role of public groups over time
- discussion of participants primary sources of information about low-dose radiation and discussion of the trajectory of their knowledge acquisition
- discussion of the primary channels of communication across groups and individual parties
- discussion of any trenchant problems facing public-participation efforts
- observations about the noninvolved public's perceptions of radiation risks
- discussion about the role of science and scientists in public participation at Rocky Flats

- expectations about future uses of the site
- impressionistic questions about how interviewees thought the site was currently viewed by the 'non-involved' and how it might be viewed in the future

Data Analysis. Virtually all interviews were taped, transcribed and coded. Coding roughly followed the above interview schedule. However, the volume of interview data focusing on some topics and not others suggested to us the importance of the content herein, namely, tradeoff difficulties, the disruptive play of fugitive values, and the changing constituency of public discussion groups. Moreover, the dynamic nature of the meeting venues and the often tense atmosphere that prevailed during meetings held throughout this research period directed our attention to understanding why the constitution of groups had changed over time, what differences in risk perception and values underlay the endless discussion of technical aspects of cleanup options, and how it was that a cohesive and knowledgeable group — this "involved" public — managed (or failed to manage) their differences of opinion as concerned cleanup.

2. Plant History

2.1 The Production Era

The Rocky Flats Environmental Technology Site (hereafter Rocky Flats) sits on a mesa sixteen miles north and west of Denver. Approximately 2 million people live in the greater Denver metropolitan area. Due to its proximity to Denver, in 1995 the DOE named Rocky Flats the most dangerous facility in the nation's cold war complex of production sites. Operating from 1952 through 1989, the plant manufactured the detonating devices at the core of hydrogen bombs. These cores are known as "pits," "primaries," or "triggers." The core's center is comprised of a "hollow plutonium shell about the size of a grapefruit but weighing seven to nine pounds . . . . A typical one explodes with the force of around 20,000 tons of TNT" (Ackland, 1999, p. 3).

The 1957 and 1969 Fires. Over the plants' multi-decade history, much of its operation went unrecognized by the local population. Several events contributed to a reversal of this general pattern. In 1957 a fire and a series of explosions broke out in building 771 where most of the molding of plutonium into pits occurred.[1] The ventilation systems in building 771, a vast structure in its own right, was designed to keep plutonium from escaping into other workspaces and outdoors. The glove-boxes in which the pits were molded, via rubber gloves, were connected by a conveyor belt system for the transportation of materials. Both infrastructural properties contributed to the fire's spread. The fire was officially put out in 24 hours. Employees and firefighters were checked for acute contamination; plutonium appeared in the fecal, blood, and urine samples of several workers in the subsequent few days. Dow Chemical's medical director nonetheless concluded that: "for all practical purposes, the plutonium contamination resulting from the fire [was] negligible" (Ackland, p. 120).

[1] Plutonium is combustible in response to both air and water and thus small fires were somewhat common though usually quickly contained. The explosions were likely caused by the combustion of volatile gasses and dust that had accumulated in the ventilation filters (Ackland, 1999, p. 119).

Table 1. Rocky Flats Timeline

Nuclear weapons development

— Manhattan Project develops atomic bomb
— 1950 Significant expansion of nuclear weapons program
— 1951 Atomic Energy Commission selects Rocky Flats site for production

2.1.1 Production Era 1952-1992

Dow Chemicals 1952-1975	**2 2.2 Rockwell International 1975-1989**
— 1952 Rocky Flats began production of "pits" — 1957 Plutonium fire in Building 771 — Plant production and support facilities expanded several times — 1969 Plutonium fire in Building 776 — 1973 Tritium incident	**2** — 1975 Terminal ponds constructed on N. & S. Walnut Creek — 1989 FBI raid (June 1989)

— EG&G brought in to safely resume production
— 1991 Water replacement project funded

2.2.2 Post-Production Cleanup & Closure Era 1992–200?

2.2.2.1 EG&G 1990-1995	**2 2.2.2.3 Kaiser-Hill 1995-200?**
— 1992 Nuclear production mission ended — 1994 Last defense-related shipment left Rocky Flats — Planning estimate for closure — 65 years (2060) $36 billion	**2** — 1996 Tri-party Rocky Flats cleanup agreement signed — 1997 Water replacement completed — Kaiser Hill planning estimate for closure — 2010, $7.3 billion — 1996-98 Building d&d begins — 2000-02 RSAL debate — 2000 Closure contract & 2006 closure agreed upon — Ongoing building d&d — over 700 structures — Ongoing environmental restoration — 2006 Closure target

2.2.3 Long-Term Stewardship

2.2.3.1 Questions to be resolved

— Ownership — Liability — Water monitoring and safety
— Land use — Maintenance

2.2.3.2

Calculating exposure for areas residents was a more difficult task, particularly as the smokestack monitors on building 771 had ceased to operate during the fire. Just over 18 pounds of plutonium was unaccounted for after the fire; later dose-reconstruction studies estimated that the fire likely released through the smokestack somewhere between 50 to 500 grams of plutonium. Microscopic quantities are dangerous if inhaled. The upper limit for exposure for a worker at the time was 1 gram of plutonium.

Successive expansions of the plant facilities, buffer area, and workforce occurred throughout the 1950s and 1960s as the U. S. nuclear arsenal increased its Cold War holdings. In 1969 a second plutonium fire broke out in Building 776. The near burning of the roof — which if it had disintegrated would have enabled a catastrophic release of plutonium into the greater Denver area in the form of a powdery ash — was of great concern. This was luckily avoided, although fifteen employees required decontamination showers having received significant doses. Local news media covered the story. Ackland (1999, p. 156) cites a *Denver Post* headline as reading: "Radioactivity: AEC Weapons Building Burns." The story's text declared the building "too radioactively hot" to enter. Were it not for the classified secrecy of post-fire reports, the possible Chernobyl-like outcome of the fire might well have outraged local residents. Nonetheless, many regard the event as an awareness-turning-point, the juncture at which the plant's threat to the community was more fully realized.

A 1973 release of tritium (a radioactive form of hydrogen) into the local water supply also received considerable media attention and launched an effort by local governments to alter the source of residential water supply; a replacement water system was completed in 1997.

The FBI Raid. The actions of whistleblowers within responsible federal agencies and escalating activism at the site in the 1970s and 1980s culminated in a 1989 raid of the site. FBI agents and EPA investigators arrived onsite with no prior warning, and seized records and photographs from 31 buildings as well as samples from outdoor waste disposal sites. The FBI's 116-page affidavit and application for a search warrant defended the stated "probable cause" that crimes [of unacknowledged exposure, disposal,

etc.] had been committed. The report was made public 3 days after the raid (Ackland, 1999, 216). Among its dramatic accusations was that waste was routinely and illegally burned in building 771. Ultimately only lesser charges were supported but widespread publicity ensured that Rocky Flat's status as a model site and employer was severely damaged.

Following the raid, charges of safety violations continued. The plant's production activities were temporarily suspended in November 1989. In the same year, the post-Dow Chemical contractor, Rockwell International, sued DOE as it found itself unable to reconcile the conflicting demands of the agency for production alongside the EPA's demands for safer environmental standards. The DOE responded by contracting with EG&G, operators of the DOE's INEL laboratory in Idaho, to prepare for resumption of production. Following a period of contentious public debate and activism, it was announced in January of 1992 that production at Rocky Flats would permanently cease.

2.3 The Post Production Era

As recently as 1993, the plant housed over 14 tons of plutonium (some in metal, the rest in compounds and mixtures) and more than 7 tons of highly enriched uranium. Moreover, thousands of barrels of contaminated waste were stacked in the hallways, rooms and parking lots on the site. Meanwhile, President Clinton's new energy secretary, Hazel O'Leary, ushered in an era of decreased secrecy on the part of DOE and high expectations for developing both a more informed public and a public actively involved in site decision making. DOE staff thus funded the 23 stakeholder Rocky Flats' Citizen's Advisory Board. "Members included plant workers, activists, academics, neighbors, and local elected officials" (p. 237).

The last defense-related shipments left Rocky Flats in 1994. That same year, the DOE in conjunction with EG&G estimated that cleanup would cost $36 billion dollars and projected an astonishing 50 years for closure. In 1997 Energy Secretary Péna (a former Denver mayor), announced that Kaiser-Hill would be responsible for a $7.3 billion dollar closure, scheduled for 2006. Then as now, members of the CAB have questioned the DOE's budgeting and decision-making process (Ackland, 1999, p. 240), a point that will be elaborated shortly.

3. Public Science, Risk Communication, and Risk Perception at Rocky Flats

3.1 Radiation Knowledge and Standards

Radioactivity refers to the "curie" or degree of energy — in the form of x-rays, beta or alpha particles, or gamma rays — emitted by the nuclei of a radioactive element as it spontaneously decays or disintegrates over either very brief or very long periods of time. The harmful effects of ionizing radiation were first recognized in 1925 (Martland, Conlon, & Knef, 1925). The behavioral properties of radioactive materials vary as do their respective abilities to penetrate tissue and deposit energy in the human body through ionization.[2] Alpha particles, for instance, are relatively large and carry a double positive charge. They are not very penetrating and can be stopped by a piece of paper. They travel extremely short distances in human tissue but deposit all their energies along their short paths, with the potential of doing a relatively large amount of damage along these paths. Beta particles (electrons) are extremely small compared to alpha particles and carry a single negative charge. They are more penetrating than alpha particles, but can be stopped by thin aluminum metal. They travel much longer distances in human tissue and deposit much less energy along their paths. Gamma rays and X-rays, having no mass or electrical charge (electromagnetic radiation), can travel extremely long distances in human tissue compared to particle radiation (alpha and beta). They deposit much less energy along their paths, but can damage internal organs (MacGregor, 2002).

From the 1940s forward, the question of whether or not there exists "a threshold for somatic radiation injury" has persisted despite repeated efforts by scientists to discern a 'safe' dose (Walker, 2002, p, 20). The question endures in part because the evidence for low-dose radiation effects are derived not from direct empirical evidence but from linear extrapolations based on effects of high-dose exposure such as that suffered by victims of the 1945 bombings of Hiroshima and Nagasaki. This process of estimating the impacts of low doses on the basis of higher doses is sometimes referred to as the "linear hypothesis." It seeks designation of comparatively safe doses based on these extrapolations yet also implies that all levels are to varying degrees detrimental to human health.

[2] Ionizing radiation can cause physical changes in human tissue because it can knock electrons from the atoms and molecules in its path.

By the 1960s new research suggested that low doses over an extended period of time were less harmful than equivalent doses delivered in a short time (p. 40), but not definitively so. Among Atomic Energy Scientists (AEC) there were strong disagreements on this point. Yet, by 1980 several prominent regulatory scientists argued that the linear model was "not appropriate . . . [because] adverse health effects increased very gradually at low doses and followed a linear model only at much higher levels" (p. 101). These disagreements about the legitimacy of a linear relationship between high dose and low dose initiated multiple debates among scientists about safe levels of exposure. In the recent period, the National Academy of Sciences' BEIR V report (National Academy of Sciences, 1990) argued that the linear hypothesis was appropriate for estimating some but not all tumor risks; hence it was suggested that the linear hypothesis was appropriate at some but not all levels.[3] Yet, by the mid-90s dramatically different opinions existed on the question of low-dose effects. Some "held that even the energy in very low doses of radiation could damage DNA strands in cells [and that] mutations that occurred in this way could lead to cancer" (p.143). Whereas others held that "cells had amazingly sophisticated repair mechanisms" and that "small doses of radiation [might even be] beneficial" (p. 144).[4]

Regulatory law, as set out by the Environmental Protection Agency, currently requires that the risks to which the public are exposed fall within a 10^{-4} to 10^{-6} risk range; that is, a 1 in 10,000 to 1 in 1,000,000 mortality risk.

3.2 Public Science at Rocky Flats

In the last two decades, a wide body of research has emerged on the role of science in society and on lay/expert debates about science. To this end, science is understood as both a set of theories and practices used in the pursuit of knowledge, a technical language employed in debates about policy, and even a "culture" with its own characteristic (and collectively held) body of beliefs. Among the many findings that have emerged from this

[3] In competition during the writing of the report were the linear model and the quadradic model; the latter posited that adverse health effects increased very gradually at low doses and followed a linear model only at much higher levels. . . . In an effort to resolve differences on this point, "most members of the committee endorsed a "linear-quadratic" model that split the difference between the two approaches" (Walker, 2002, p. 101).

[4] Hormesis is the theory that low doses of radiation are in fact health-beneficial.

new field is the paradoxical social fact that most public groups are strongly supportive of science at the same time that there are many heated public debates about the validity of science as it applies in particular policy and decision-making contexts. This later point is particularly salient in the case of nuclear technologies where strong 'scientists versus the public' differences of opinion occur about the safety of nuclear technologies (Krimsky & Golding, 1992). Briefly stated, it has been found that much of the public disagrees with the expert community about the safety of radioactive isotopes if the source or location of those materials is also associated with weapons development, nuclear power, and nuclear waste. Moreover, it is a well-established that government agencies assigned with the management of these technologies are distrusted by much of the general public (Slovic, 2000). Scientists and regulators have often viewed this distrust and difference of opinion as either (1) a problem of scientific and technical illiteracy on the public's part (a failure to understand the science and hence a fearful or resistant attitude) , and/or (2) a problem of poor quality education and communication on the part of experts. Risk communication and public education is often regarded as the universal remedy for this problem and many approaches have thus developed to improve risk-communication practices (National Research Council, 1996).

Risk communication at Rocky Flats consists of an ongoing dialogue between the DOE, EPA, a citizen advisory board (CAB), one of the few fully independent citizen boards in the DOE complex, and a coalition of local municipal and county governments (RFCLOG).

3.3 Scientific Enculturation

The Rocky Flats risk-communication program has been remarkably successful in that many citizens have achieved an impressive level of technical sophistication about cleanup operations and probabilistic risk estimates. As such, conversations about the effects of varied decommissioning strategies, the implications of wind patterns on contamination dispersal in future open space, or the long term health effects of low-dose exposure from different levels of plutonium concentration in the soil are publicly debated.

This technical expertise was not easily achieved nor acquired by all participants. Rather, a core group of particularly knowledgeable participants became the predominant and most vocal public stakeholders at Rocky Flats. For those participants without significant training in the natural sciences or engineering, there existed tremendous normative pressure to "come up to speed" on the technical dimensions of cleanup before one could rightfully participate. Public participants readily admitted that the burden of becoming technically literate was enormous and that considerable effort had to be invested in order to participate meaningfully. Many, though not all, took this as a challenge worthy of pursuit.

> When I decided to interview for the CAB, I knew right away that it was going to be a very steep learning curve, because it was about a whole lot of policy issues I hadn't encountered before and also a whole lot of scientific arguments that I was only minimally aware of . . . and so god bless the activists who have thrown away all hopes for an otherwise bourgeois life to read the library.

In the words of another participant:

> To have a meaningful public process, you have to have an informed public. To be informed takes a lot of work. And most people don't even read a newspaper, let alone a [soil action level] report which is that thick. I spent last Tuesday doing that. I sat down and read it from cover to cover. It takes a lot of effort if you want to get informed.

For those who had only recently joined the CAB, the prospect of earning credibility as a public participant through intensive study and training was particularly daunting:

> Just learning all about the different terminology. That has been an education in itself. It just blows me away sometimes. It's like, OK, what did they mean by that, you know? And I have my little list of acronyms that I can relate back to . . . [I'm just going to] make sure that I'm up on everything, read all the material, which is mountains, mountains of material. It's a monumental task.

Moreover, new CAB members regarded scientifically trained and more literate, long-term colleagues with what can only be described as awe: "These people have been doing this

for all this time and it's just, I find, remarkable. I really do and I really respect them for their dedication to it. It's been . . . an eye-opener."

3.4 Perceived Risk at Rocky Flats

Given the evolution of technical literacy at Rocky Flats among a core group of participants, it is appropriate to ask: (1) how knowledgeable this subset of participants is about the radiation risks and standards and (2) how fully their perceptions of risk conform to existing studies on the subject.

Nearly three decades of studies of the public perception of radiation risks has revealed that risks affiliated with nuclear power, weapons and waste are particularly salient in the public mind. They are regarded by the public as highly risky technologies as compared to most other sources of radiation exposure such as x-rays, cosmic radiation, sun, nuclear medicine, and radon (Slovic, Fischhoff, & Lichtenstein, 1979). More specifically, the characteristics of a hazard — whether it is seen as dreaded, involuntarily imposed on those exposed, thought to be beyond one's control, or regarded as unfamiliar — powerfully effect the perception of risk (Erikson, 1994; Slovic, 1987, 1992). It is argued that people fail to understand the relative or comparative importance of different risks — of low-dose radiation stemming from a nuclear power station as compared to, for instance, the risks of handguns or smoking. Equally, the public generally fails to understand the probabilistic reasoning and risk ranges that underpin expert risk estimates (Morgan, Fischhoff, Bostrom, & Atman, 2002). Studies of people's intuitive thinking about risk also reveals that most people evaluate radiation hazards on the basis of the source of exposure (i.e., the dose delivered by a medical x-ray is not thought to be as bad as an equivalent dose delivered by contaminants remaining from bomb production). Finally, in repeated surveys, Europeans and North Americans reveal themselves to be dose insensitive. That is, lay persons (as compared to experts in the toxicology and risk assessment field) are far more likely to believe that "there is no safe level to a cancer causing agent" and that even a small dose of a carcinogenic material will cause cancer or serious bodily harm (Kraus, Malmfors, & Slovic, 1992).

At Rocky Flats, however, the long-standing risk-communication program initiated by state and federal agencies as early as 1993 and the high epistemological standards that

came to characterize public discussions at the site resulted in a somewhat different pattern of knowledge and perceived risk. Fifteen of those interviewed from the core group of involved stakeholders were sufficiently comfortable technically to offer their own models and understandings of radiation risks and standards. Six of the fifteen can be characterized as regarding low-dose radiation as comparatively safe, two as cautious but undecided, and seven as leaning toward a characterization of low dose as unsafe. Only one of the fifteen offered "inaccurate" information about the behavioral attributes of radiation, or the meaning of the linear hypothesis, background radiation, exposure pathways, comparative risk ratings, and/or the probabilistic ranges of risks that mattered for regulatory purposes.

In sum, these core participants were extremely knowledgeable about the characteristics of ionizing radiation. They understood the difference between alpha particles and gamma rays and the kinds of mitigating protection each required.

> I have a fact sheet on beta, gamma, and alpha radiation, and what penetrates and where it penetrates. Alpha can be stopped by a piece of cloth. . . . The only radiation that people understand is high-dose radiation. It makes you vomit, it makes you sick and then you die. They've got a clue about that.

Several core participants also understood the concept "below regulatory concern" and were cognizant of debates about the linear no-threshold (LNT) versus threshold models of dose and biological damage to human tissues.

> [Low dose is] a non-acute dose . . . no [detrimental] observable response in the body . . . But, you know, I really think that we just don't know. It may be far more dangerous than we think. They [theories of low-dose radiation] go from linear no-threshold to hormesis.[5] But, right now, things are based on the linear no-threshold theory and there are enough people pointing to evidence that this [theory] is correct.

Many could also readily offer tutorials on the linear no-threshold hypothesis and were aware of both its meaning and its link to evidence historically derived from high-dose

[5] This speaker was at all times careful to identify his own view in reference to others, and to characterize the perspectives of others carefully and respectfully.

exposure. When asked the meaning of low dose, one participant offered a graphical explanation and in so doing drew a invisible x-y axis in the air:

> Well if you have a chart of exposure and time [and] it's getting down near the zero point, and I haven't spent a lot of time studying this, [but I know that] we don't have much data in this area. You know a lot of the studies or extrapolations of potential harm from radiation are based on high intensity, concentrated high dose.

Importantly, it was also the case that most participants were dose *sensitive* in that they understood fully the relationship between dose and hazard. Some could recite the comparative risks of different naturally and non-naturally occurring forms of radiation exposure as an expression of either millirem dose annually or as an expression of cumulative lifetime dose. Discussions of dose tended, instead, toward the more arcane and context specific influences of exposure such as the duration and intensity of exposure (chronic versus acute), pathways of inhalation or ingestion, physical attributes of the contaminant (gamma ray or alpha particle) and/or the age or vulnerability of the dose recipient.

The most notable difference between the knowledge articulated by those who were risk-averse as compared to those who were risk-tolerant were the technical points on which emphasis was placed. Those who represented themselves as less apprehensive about the health consequences of low-dose radiation, were more apt to highlight, during interviews, the high levels of local background radiation extant in the Colorado and greater Denver area,[6] the mortality risks of other commonly encountered risks, the failure for some of the more dire predictions of radiation hazards to materialize, and to regard the by-products of nuclear weapons as an understandable risk in face of necessary Cold War benefits. An illustrative excerpt from a 'risk-tolerant' CAB member is as follows:

> Many houses have very high radon here. . . . We're also at a higher elevation. Why, if it's ten times what it is, say, on the eastern seaboard, why don't we see some observable differences. Now I agree, it's very difficult because we're looking for a signal in a sea of noise and it's a fairly affluent society we have here. But . . . I would

[6] Discussants were also aware of the vagaries of determining background radiation such as soil type or geological features, altitude, radon levels in individual households, etcetera.

> expect to start seeing something at least. And even more so among airline pilots who are absorbing over a rad a year . . . and flight attendants too . . . .
>
> One of my pet peeves is that I have a very difficult time between risk perception and reality, real risk. I don't see why they're not the same. And I know that's totally — but people get in their cars every day and accept at 10-4 risk of dying in their car from auto accidents. Now, ones that drive aggressively probably have a 10-3 [risk]. People that drive drunk probably have a 10-2. So, we accept all these risks, but somehow radiation is in a different category. . . .
>
> And then there's another way to look at risk, risk-benefit. This is where people philosophically on radiation part company very quickly. Were nuclear weapons a benefit or were they a hazard, solely a hazard with no benefit? I personally would ascribe a large benefit to nuclear weapons, and I think we would have been in a war with Russia within two years after World War II if we had. Now, that's my own belief. There's a lot of people that take the opposite side.

A similar pattern of thought is provided by another CAB member. This speaker did not explicitly state an opinion regarding the Cold War, but something of an opinion can be gleaned from references he made to those in the group regarded as motivated by anti-war activism.

> There are those that come with their political agenda, anti-nuclear, anti-war agenda, that aren't going to be happy no matter what happens…
>
> Living in the front range you get 250-300 millirems per year from background. You take a couple flights on a get plane and you'll get 25 additional millirems. It's a perception about the danger. I think there are those that are extremely fearful of radiation. And there are those that accept radiation as just part of life. I mean we live in a radiation environment, there's nests of radiation all around us.... By choosing to live in Denver, you live in a higher radiation area for two reasons: Number one is altitude, number two is because of the high uranium concentration back in the mountains.

> [Yet], apparently, we're not a bad species. We've got two hands, two legs, two eyes. It hasn't had terribly severe effects on us. You go get dental x-rays, you get a pretty healthy dose. You get a chest x-ray, you get a pretty healthy dose.

Those who represented themselves in interviews as risk-averse were more likely to emphasize the possible detrimental effects of single inhaled particles when articulating their understandings of radiation risks. They were also somewhat likely to emphasize the uncertainty inherent in scholarly understandings of radiation science and/or to exercise a precautionary approach by drawing the "acceptable" line at the conservative end of the risk range set out by federal policy, that is, a 10^{-6} risk.[7]

By way of example, one participant offered the following thoughts when questioned about the meaning of low-dose radiation. In so doing, he pointed to a photograph of a plutonium particle, magnified 500x, in the lung of a human being. The photograph portrayed a star pattern of tracks emanating from the lodged particle.

> This set of alpha tracks occurred over a 48-hour period. This is one particle of plutonium. In the lifetime of a person with a particle like that, it's going to affect a lot of cells and it may damage some. It may kill some. If it kills them, that's helpful, but if it damages them, that's not very helpful. I know this is very controversial. Not everybody will [contract cancer.] It's a gamble, a person may contract cancer or genetic defects or some other health effect from that particle of plutonium.

A second participant also explained low dose as an emanating single particle. Earlier in the interview, we had discussed her knowledge of state and federal surface water standards for plutonium, exposure transmission routes for heavy versus fine particles of target materials, and the possible error rates of monitoring systems that sample local water reservoirs at 30 versus 7 day intervals.

> Well [in reference to low dose], you have to talk about low energy, high energy, etc. At Rocky Flats we have high energy, plutonium. Plutonium is considered a high-energy source, an alpha particle.

[7] We do not mean to suggest that the 'risk-tolerant' participants never mentioned the effects at the cellular level of a single exposure, they did. Our point is that the knowledge content most emphasized followed the patterns noted above.

She then switches to the behavioral attributes of beryllium to illustrate her thinking about the meaning of low dose. Beryllium exposure was newsworthy during this period, as reports of a compensation settlement for exposed workers had recently appeared in local headlines.

> Last year, a local doctor from DOE was out here talking about beryllium. A city councilman asked him about how much exposure a person [can] have before they [should be] concerned. And he said, "one." One exposure. Just one. He said that it only takes one particle in your lung. It keeps giving off energy. It's the gift that keeps on giving. That's what the workers call it. The gift that keeps on giving. One hot little particle sits there and does its damage. And for the worker, that really is the primary exposure.

Scholarly uncertainty across efforts to determine safe doses and personal control over the risks to one's health were also cited as reasons to endorse a conservative cleanup. In one illustrative example, an active public participant noted that it takes a very long time to demonstrate the health effects of different exposures. Citing the relatively simply case of smoking and lung cancer, the speaker characterized efforts to understand low level radiation as a parallel albeit more complicated case. "Low level radiation is the same sort of thing, it's a long range low level effect, very difficult to prove." Because it is difficult to prove, and, he noted, won't be understood with any certainty in the near future, the salient point for this participant was the difference between the risks that one has no control over (such as a natural disaster) versus those risks that are imposed on citizens.

> An acceptable risk is one that there is a zero possibility of controlling, a lightening strike. Random acts of god. An unacceptable risk is something that man has designed and has some control over. I like the 10^{-6} number, one in a million. I like my chances better.

The above informed characterizations of low-dose radiation do not defeat earlier work on perceived risks. It is still the case that control over risks figures prominently in the acceptability of risks, as does thinking about dose sensitivity, albeit to a far more nuanced degree. Those who are risk-averse and understand the complexity of dose

estimates might still focus on the ‘chance’ that some people will suffer severe damage following an inhaled single particle or minimal physical insults. Those who are risk-tolerant continue to hold the point that the source of the risk does not matter — that citizens should think in terms of comparative risks and thereby tolerate risk exposure from Rocky Flats in the same manner that they tolerate exposure to the effects of living at high altitude or flying in a passenger jet. Thus, while risk communication at Rocky Flats reflects improved local knowledge of radiation risks, a clear distinction in patterns of thought between those who are risk-tolerant and those who are risk-averse remains evident.

3.5 Science as a Rationalizing and Tension-Reducing Force

It is difficult to determine precisely when and how a high intellectual standard and accompanying technical discourse was established at Rocky Flats. Two general points are relevant. First, a more technically trained and focused CAB appears to have replaced the activist climate that characterized the period between 1990 and 1996. Several long-time CAB members identified a gradual decrease in community and anti-nuclear activism among CAB participants and attendees at open meetings.

> There were a lot of people who had been historically involved from an activist perspective. And that wasn’t all that was on the CAB, but that certainly influenced the sort of flavor of it. And we have a lot more now who have no historical connection to the work at the site, or the issue in any way. And some who I would characterize as being probably more conservative, including _____ [who is] still doing contract work [as a radiation scientist] at Los Alamos.

Second, as the site began to approach a 2006 or thereafter cessation of cleanup, the pressure to resolve some of the more trenchant debates escalated — debates about how safe is safe enough and how best to proceed with the decommissioning of buildings, the decontamination of soil, or the viability of institutional controls for monitoring residual risks. The increasingly technical discourse is linked to that pressure to the extent that the rationalizing forces of science were expected to resolve these debates.

Advocating the "best available science" as a rationalizing and hence guiding principle for cleanup decisions is a laudable goal and cleanup — most would agree — should be guided by a high standard of technical rigor. But such efforts do not necessarily forge a more effective public process. Indeed such assumptions contradict 20 years of work on effective risk communication (Fischhoff, 1995; National Research Council, 1996; Powell & Leiss, 1997).

4. Tradeoff Avoidance

It is our contention that it was not a failure of scientific literacy at Rocky Flats (e.g., a failure for the involved public to 'understand what is meant by the numbers') that exacerbated conflicts about cleanup, but, rather, a failure to take up and resolve the tradeoffs that were to determine what to do when and to what level. That is, one single variable appears to drive most of the conflict, stress, and at times the breakdowns of public processes at Rocky Flats. This is the pronounced difficulty regulatory agents (primarily from DOE and the Environmental Protection Agency), the contractor (Kaiser-Hill) and the involved public (the Citizen Advisory Board, the Rocky Flats Coalition of Governments as well as a handful of individual participants) all have both facing and addressing the tradeoffs intrinsic to the cleanup process.

If scarcity of resources (in this case money for cleanup) were not an issue, the tradeoff dilemma would be nonexistent. But there are in fact very few arenas in which citizens can expect unlimited resources.[8] Put simply: If the federal government and the contractor were both willing and able to deliver on the idealized requests of the involved public, the grounds for conflict and controversy would be greatly reduced. Instead, a sometimes-agonizing struggle (locally referred to as "brain damage" or the hard work of public discussion) had evolved from efforts to resist, avoid, or circumvent any real and perceived limitations on cleanup of the site and hence to resist the necessity of making difficult tradeoffs involving particular gains or sacrifices.

The tradeoff impasse is a familiar one: Vocal critics of Rocky Flats cleanup activities reject fiscal and temporal limitations and maintain that the agencies and contractor must

[8] We assume, of course, that concerned citizens will act in accordance with the conviction that it is their job to realize as much return as possible through political pressure, scrutiny of decision process, and the electoral and interest group venues.

spend whatever it takes to clean up the site. In contrast, the agencies and contractor have consistently worked from the assumption that they would pursue the best possible cleanup within the limitations of available time (i.e., a cleanup deadline of 2006) and funding. Clear statements regarding the divergent views of the DOE, the EPA and members of the involved public were apparent, both in the public meetings, and in our interviews with participants. For example, one member of the citizen's advisory board stated:

> You know, this whole issue about what the cleanup level's gonna be. I don't get that. I'm like, are you gonna clean it up or are you not gonna clean it up. Why are we negotiating what the cleanup level's gonna be? I don't get that. If I can go out there with a Geiger Counter when you're gone, am I gonna get a click? What, what are we, what are we negotiating?

The above example represents some but not all of the perspectives of involved citizens. The following comments were, for example, typical of contractor and agency perspectives, but were also similar to the opinion of several CAB members.

> It's all about this tradeoff. [But certain groups] reject the time line and reject the budget. The fact is that the fiscal constraints to this contract are so blatantly real that we just have to emphasize [the fact that]: Four billion[9] dollars is what [Rocky Flats is] getting, it's irresponsible to ask for more. And that message has been conveyed by the congressional office,[and] on a one-on-one basis to some key people. But, you know, the way I look at it is: the government has basically said that they're willing to give Rocky Flats four billion dollars to clean this place up. And, that's a whole lot of money. And, we can get a great cleanup for that. And, there's a lot of possible outcomes on what the end-state looks like.

Over the multi-year period of public process at Rocky Flats the necessity of making time and cost limitations clear has repeatedly come up against the perceived negative consequences of this assumption. To some extent, the contractor and the two agencies

[9] The overall budget for clean-up was earlier stated as 7.3 billion dollars; the amount cited here only included estimation of cost and does not include Kaiser-Hill's fee for the project. That fee will go up or down depending on unanticipated costs as well as cost to the company for fines levied due to time overruns and related unmet contractual obligations.

(DOE and EPA) found themselves in a classic decision maker's quandary by virtue of the expectation that they could minimize public conflict and simultaneously cope with a wide range of technical and financial uncertainties. In regard to the first expectation — minimizing public conflict — we were explicitly informed by agency personnel that the DOE and Congress had produced an agreement that guaranteed yearly appropriation of funds for the Rocky Flats cleanup as long as three conditions were met: 1) the cleanup be completed by 2006; 2) the cost and scope of the cleanup be contained (i.e., remain as negotiated); 3) conflict in the community be curtailed (given the history of public protest at Rocky Flats). This agreement, made in trust, was (and continues to be) validated through ongoing annual appropriations to Rocky Flats. Rocky Flats was in an advantageous position in that very few of the other sites in the DOE complex had been guaranteed (albeit conditionally so) annual appropriations. But as those funds were "conditional", the contractor and the agencies were placed in the position of having to 'minimize conflict' while meeting bottom-line budget limitations regardless of any certainty that cleanup could actually be achieved with the available resources and within the agreed upon time line.

Those who study the difficulty people have making tradeoffs recognize that they become vastly more complicated when the degree of uncertainty about whether the actions taken will deliver the desired consequences is high (Gregory, in press). Uncertainty can be magnified both by "epistemic uncertainty" or lack of knowledge (i.e., the situation poses questions that science cannot yet answer) and by the behavioral complexity of the system being studied (i.e., uncertainly about future wind patterns, soil migration, flooding, and other such events at Rocky Flats) now and long into the future.

4.1 The RSAL Debate

The complexity of tradeoff considerations and their intersection with an heightened scientific discourse was nowhere more evident than in the multi-year discussion among stakeholders about Radionuclide Soil Action Levels or RSALs. This level refers to the maximum volume of radioactive materials found in the soil above which cleanup or removal of that soil is required. The implications for where the RSAL is set at Rocky Flats are enormous as soil cleanup represents the single largest remediation action at the

site. The decision dramatically influences the availability of resources for other decontamination measures. Moreover, there existed considerable external pressure in the form of the possibility that the RSALs set at Rocky Flats would establish a profoundly burdensome precedent at DOE. A low RSAL at Rocky Flats could mean exorbitant cleanup costs throughout the complex if DOE was held to the Rocky Flats standard at all sites. This is particularly the case given that some other sites are considerably more contaminated than Rocky Flats.

Setting an RSAL is a complex and uncertain science as it concerns the ability to accurately predict low-dose radiation for future users of the site from residual contaminants in the soil. Anticipated average annual doses can only at best be reasonably calculated based on a wide set of variables and assumptions including but not limited to:

1. Characterizations of the site including such variables as wind patterns, hydrology, soil morphology, slope, and so on, each of which contribute to a particular pattem of soil migration and contaminant concentration within and beyond the site.
2. Expectations about the future users of the site (suburban resident, subsistence farmer, recreational user of open space, wildlife worker, etc.) and the calculation of exposure for a 'typical' user.
3. Expectations about what activities characterize the likely movements of a future site user which in turn helps determine their rate of inhalation — or ingestion-derived exposure.
4. Expectations as to what a safe maximum annual dose is — given the uncertainties of hypothetical dose constructions and the heterogeneity of contaminant concentration.
5. Expectations regarding the likelihood of adequate institutional controls in the immediate future (50-100 year period and beyond).[10]

The DOE had initially proposed a maximum allowable plutonium RSAL of 651 picocuries per gram of soil whereas others had identified an RSAL of 35 pCi g^{-1}. Those rallying for a conservative RSAL (and hence a more thorough cleanup of soil) hoped that

[10] How does one manage for the future when the capacity to engineer controls or monitor the dispersal of residual contaminants when dealing with material (e.g., plutonium 239) with a half-life of 24,065 years?

the “subsistence farmer” (aka “resident rancher”) affiliated with the 35 pCi g would become the prototypical future user. [A resident rancher was defined as a person who lived full-time on the land and would grow and consume products from that land.] Others promoted somewhat less conservative scenarios including RSALs for a wildlife worker and a recreationalist. [A wildlife worker would manage the open space refuge that Rocky Flats would become, spending approximately 40 hours a week on the land. A recreationalist might only occasionally hike, jog or mountain bike on the same land.]

Under these circumstances it was essential that the responsible contractor and agency parties be utterly and consistently clear about the contextual factors (e.g., the budget assigned by the federal government) within which cleanup must take place. Without early and constant clarity, a “risk information vacuum” invariably surfaces to undermine future communication and possibly amplify the public perception of the risks involved (Powell & Leiss, 1997, p. 214).

Yet, however closely regulators were working with the involved public, our data suggests that the contractor and especially the DOE were ambivalent about making the cost/time/RSAL tradeoff explicit. Agency parties (DOE and EPA) and contractors (K-H) represented themselves as intent upon communicating the concrete reality of these constraints (and as having made these constraints clear all along). But this is contradicted by evidence from stakeholder meetings and several members of the public who regarded the agencies as having actively concealed the “true” nature of these fundamentally limiting ‘time and cost’ variables. As a result, there existed widespread suspicion about the possibility of “behind closed door” negotiations. The assumption was that federal parties had acted unethically and against the well being of the local community and that as such public participation was nothing more than a vacuous procedural gesture.

In June 2001, a particularly illuminating encounter was observed at a meeting of the RFCA focus group, a meeting regarded by many as the central point at which fiscal limitations (and hence the need for difficult tradeoffs) were first brought out into the open. Heretofore the tradeoff discussions had been masquerading as a technical discussion wherein the defensibility of the studies used to set RSALs were called into question.

The meeting was significant enough for the DOE representative to describe the exchange as a, "momentous discussion" and to characterize it as "throwing a dead rat on the table" — the "dead rat" being the fundamental limitations posed by a cost ceiling and hence need for tradeoffs. [Note, he is ostensibly admitting that only here was the tradeoff made explicit despite claims made in interviews with DOE personnel that tradeoff necessities had always been openly declared.] The exchange recorded below occurred midway through the meeting; it begins with a private citizen and long-time participant in the public process initiating a discussion about the future user of the site:

> *Citizen:* This is presumably a dead horse but I hope it is not . . . The RAC study[11] used a Resident Rancher because it is most conservative. Is that [possibility] really dead? We can't possibly say what will happen in 500 years . . .
>
> *EPA Staff:* We base our assessment on reasonable maximum risk, but I don't think a [resident] rancher is that— I won't tell my boss that. Plus, a refuge worker is still conservative and reasonable.
>
> *Citizen:* Would Christopher Columbus have been able to tell us how we are going to use the U. S. in 500 years? . . . that is totally unreasonable for you to say that it is reasonable . . .
>
> *DOE Staff:* The agencies are constrained by laws, regulations, and policy. Furthermore we have to strike a balance here between what can be done in this place, at this time, and with this money . . . To put it bluntly, the RAC study was "unconstrained." We don't have that freedom . . . we have to depend upon institutional controls. In the interest of intellectual honesty, we have to work within these limitations.

The DOE representative's emphasis on "intellectually honesty" brought the fiscal constraints around cleanup out from the shadows of "technical" and "scientific" discussions of RSAL and future use determinations. Through this candor, he attempted to include the public in the burden of these constraints so that more detailed decisions concerning tradeoffs within the established limitations could begin to be addressed.

[11] RAC stands for the Risk Assessment Corporation, the consulting group responsible for the CAB-initiated study of RSALs noted above.

Two outcomes followed in this and a subsequent meeting: (a) the critical public resisted the idea that the tradeoff had ever been made explicit and (b) treated the very idea of a tradeoff necessity as the product of corruption and deceit on the part of the DOE and the contractor, a deceit that is conceivable given the initial ambivalence of agency parties about revealing the necessary tradeoff in the first place.

The following exchanges demonstrate this clearly. In the first meeting, a citizen refers to the DOE agent's honesty and "thanks" him for being forthcoming: "Thank you for saying this, for this is the first time I've heard this said by any one of the agencies."

At a subsequent meeting, the issue of tradeoff deception is again central. Evident, on this occasion, is the fact that lack of transparency about tradeoffs has lead participants to doubt the legitimacy of their participation in the first place. His comments reflect the dissonance between the public's expectation that their comments are influential, and a growing awareness that the limits of the cleanup were predetermined by political and economic decisions that are beyond their sphere of influence. This is forcefully expressed in veiled accusations of foul play and open statements of dissatisfaction that lead, eventually, to the request that citizens be permitted an opportunity to address the "real" principals/decision makers.

> The decision-making process is a lot more complicated, and there is a lot of subtlety, and there are a lot of pressures that are hidden to the people that come to these meetings. One of the reasons that I am interested in having an earlier meeting with the principles is because I think that they're entitled to hear from people that are unhappy with some of the decisions we've already been told have been made. They're entitled to hear from us, not just from the coordinators [on-site agency personnel]. The coordinators are clearly not the only decision makers about the soil action levels — despite the kind of neat logic of your presentations. And I realize they play a very crucial role. Take one item — which is the decision I've heard criticized a great deal, and that's the decision about the [future user] scenario that will be employed for calculating the soil action levels. We've been told that decision has been made. There's a good bit of unhappiness in this room about that decision and in the people that come to these meetings. And I suspect that there will be, beyond this, when the

news is available to people about the decision that has supposedly been made. But how — I'm really, I'm really, really interested, how that decision was made. Who made it? . . . If we can understand who is weighing in, then we know that we need to approach those people. Cause' those people are participating in the decision. I really, I really want to know. I think we're entitled to know.

Agency personnel then respond to the accusation that RSAL decisions were predetermined. In so doing, they articulate the regulatory rationale for their decision and argue that although the decision may not be consistent with the priorities of their critics, the public voice has nevertheless been included in the decision-making process. It is instructive, equally, to note that the effort to discuss tradeoffs has been dropped; discussion has returned to or been sublimated into a debate about the technical defensibility of different future user scenarios. In other words, a discourse of policy and scientific standards is used to neutralize the underlying tradeoff conflict.

EPA Rep: Well, from EPA, the status as I see it has been, was put forth in the latest revision to the Task I report, and it does have the wildlife refuge worker being the anticipated future user. And I — unless something comes up to change my mind, that's the recommendation I'm going to make to my [superior]. And I know of no other entity outside of — well I know of no other entity whose weighed in on this.

Citizen: Has that recommendation been made to your principle?

EPA: I told him that's the way I'm leaning.

Citizen: But it's your personal decision? .

EPA: It's supported completely by all the EPA policy I can find, and I vetted it with my attorney.

Citizen: So it's a recommendation to the principle at this point-

EPA: That's correct.

At this point, a DOE representative steps in to validate public process and the collective effort extended to generate and evaluate the 'risk numbers.'

DOE: I think the retort is a bit disingenuous. There's been a lot of process to decide what assumptions we should use to develop the numbers. We agreed that we needed to make assumptions about land use to develop the numbers. We ultimately, as a result of this process, are developing like five or six sets of numbers. And that's great. But the principle recommendations on things like land use, or the risk or dose basis for the number, are coming from the principles. We're not all sitting around in our showers and just deciding what sounds good. There's been a lot of process here. There's been the working group. There's meetings — technical meetings everyday. And so ultimately it comes to convergence at some point. When this came up [previously], I didn't want to mislead you; say, "no, it's wide open. We got the whole table and anything goes." Could a [RSAL] number anywhere on that table come out? Yes. Do we think that the number is going to probably coincide with the row that says "wildlife refuge worker?" That's probably going to be our recommendation unless some new information comes to bear that just throws that out the window. So, semantically, has a decision been made? No. Does it look like the Rocky Flats Cleanup Agreement principles are going to recommend that scenario as the basis for the RSAL. Yes.

Citizen: You're going round in circles. Someone wrote down in the write-up, whatever you call it — that was a decision. Now we are trying to find out who made that decision?

DOE: No, you're hearing what you want to hear. There's been a lot of process to develop information to determine what the most likely future land use would be. It doesn't mean that the outcome was always the one you wanted, but you absolutely influenced how these decisions were made.

To summarize these points, a central part of the trust compact made with Rocky Flats parties and Congress was that budgetary and time limitations would be met at the same time that public dissatisfaction would be contained. Given this informal mandate, these limitations eventually had to be broached by agency personnel. And yet, participants reacted so strongly and suspiciously to the suggestions of a cost tradeoff that all explicit mention of tradeoff limitations were thereafter avoided. It is not surprising that discussion

of tradeoffs was so quickly and easily converted to accusations of deal brokering between Congress and the agencies. In order to both avoid public controversy and cope with numerous technical unknowns, the central issue of economic and temporal limitations was not, and perhaps could not, be addressed directly. Instead, it was couched within the language of the RSAL and future user decisions. This sublimation of the basic conflict provided a mechanism through which discussion and negotiation could proceed and anticipated public resistance could be postponed and contained. However, the endurance and intensity of the subsequent debate over standards such as RSAL and the future user added to the public impression that their hard work and sustained input would be directly reflected in the cleanup decisions made at Rocky Flats. Public participants believed that they were influencing decisions that addressed their core concerns over cleanup. Moreover, the sustained discussion about RSALs (several years in entirety) reinforced the expectation that cleanup standards would be based upon a combination of public interest and scientific analysis, rather than fiscal/temporal limitations per se.

4.2 Taboo Tradeoffs and the Tradeoffs-Values Link

Tradeoffs are difficult because they are linked to value positions. We care, often deeply, about achieving outcome A over outcome B because the former is seen as fulfilling a desired value or goal more fully than the latter. Achieving one objective or valued goal comes at the cost of giving up something else of importance (e.g., deciding whether to base RSALs on protecting the health of the most vulnerable citizen at additional costs versus protecting the health of the average citizen so as to realize cleanup gains elsewhere). Yet rather than developing the tradeoffs so as to render explicit the values or objectives of different participants, public discussion fell into the default position of trying to increase scientific literacy to produce a more rational debate unencumbered by value disagreement. As a result, the RSAL discussions became paralyzed by the sublimated value issues because the very values central to the tradeoff dilemma had to masquerade as points about the scientific defensibility of RSAL modeling parameters.

Critical members of the involved public responded negatively and with suspicion to the DOE's suggestion that cleanup was constrained by cost precisely because they were

being asked to engage in what, borrowing Fiske and Tetlock's (Fiske & Tetlock, 1997) term, is known as a "taboo" or nonnegotiable tradeoff in which affiliated value positions are treated as "protected" and thus exempt from negotiation (Baron & Spranca, 1997; Baron & Leshner, 2000).

Taboo tradeoffs arise when people are asked to pit an important value intrinsic to a tradeoff against a qualitatively different category of value. Such tradeoffs lead respondents to believe that they must sacrifice a deeply held principle in order to participate in any negotiation, tradeoff, or decision process. This is particularly the case when strongly held normative positions from one sphere of life (e.g., beliefs about justice, fairness, democracy) come up against utilitarian values such as cost or time concerns. People generally regard such tradeoffs as undermining the integrity of the first set of values (e.g., justice, fairness, etc.). For example, to compare or evaluate the importance of one's children in juxtaposition to the cost of raising them is morally offensive to most people. Such acts reflect back to those making the tradeoff something "ugly" about themselves or their personal integrity precisely because they are asked to behave as though willing to transgresses important norms including the idea that "parenthood/childhood is priceless." Consciously or not, in the Rocky Flats case, public participants act on the premise that they are being asked to "sacrifice" human health for "dollars."

Moreover, when faced with tradeoffs that are actually or ostensibly taboo, a common set of "hallmark" reactions often occur. Among the hallmarks identified by Baron and Spranca (1997) and evident at Rocky Flats are:

Absolutism or Quantitative Insensitivity. This is the "all or nothing" quality of responses to taboo tradeoffs. People tend to believe that a small scale expression of an act is just as bad as a large scale one. The woman quoted above who negated negotiations with a concise: "are you going to clean it up or not" is a case in point. Under these circumstances, it becomes very difficult to discuss the 'wisdom' of variations in scale. In the RSAL case, the DOE began with a comparatively high number (651 pCg). What followed, save for a brief "dead rat/tradeoff" discussion, was several years of public effort to criticize the technical viability of that number and in so doing "use science" to

drive the number as low as possible. This is a perfectly understandable strategic reaction. But is it wise for those involved? If DOE had discussed, early and clearly, the cost limitations within which they were working, a different conversation might have occurred. Driving the RSAL as low as strategically possible might have been replaced by a better quality conversation on cost and scale. For instance, if a soil cleanup based on a 35pCg RSAL were to cost *x* dollars, while a 40pCg RSAL would cost 30% less yet represent only an infinitesimal change in health risk, it might be wise to spend the 30% saved elsewhere. (There are often diminishing returns for dollars spent, that is, the first ½ of dollars spent realizes huge gains whereas the 2nd half of gain-per-dollar outcome is much poorer.) That 30% expenditure might have gone to realize a better health-protecting gain (the value behind the tradeoff) elsewhere.

Denial and Resistance. People often refuse to believe that they must face a taboo tradeoff in the first place and thus suspend the tradeoff/decision-making process until a more palatable option can be found. There were many expressions of this at Rocky Flats. Most obviously, the wish to talk to the principles/decision makers is driven in part by tradeoff resistance. In the words of one CAB member protesting against cost and regulatory limitations: "This can be influenced by the community, and you could make these kinds of recommendations to your bosses (i.e., reject the limitations on our behalf). That is not how this decision has to be made."

The Slippery Slope Dilemma. This is the belief (and sometimes very real possibility) that any move in a particular direction will lead to or is symbolic of devastating future outcomes. The slippery slope problem is akin to legal decisions established on the basis of a minor infractions but ultimately contentious because they hint at the undermining of such inalienable rights as free speech. It's expression is well represented in the above noted concern that a high-RSAL precedent at Rocky Flats will lead to poor quality outcomes at other sites in the DOE complex.

Given the thorny nature of taboo tradeoffs, those whose regulatory mandate it is to ensure that the tradeoffs are made must develop tactics to cope with the "perilous social

predicament of attempting a taboo tradeoff."[12] Equally, they must address "the righteous indignation of observers who learn that sacrosanct normative boundaries have been transgressed" (Fiske & Tetlock, 1997, p. 285). This quandary often means that agency representatives (the tradeoff brokers) must adapt several tactics so as to deflect blame and ensure peace. These include the need to compartmentalize categories of discussion by explicitly invoking distinctions between spheres of consideration and negating the possibility of discussing two linked points simultaneously (e.g., to say "that's a justice concern, we're only talking here about technical issues"). Other tactics involve obfuscating the tradeoff and procrastination (p. 257).

4.3 Tradeoff Avoidance and Fugitive Values

Thus far, we have outlined a particular pattern of behavior at Rocky Flats. We have noted that a state of proficient and/or increased scientific literacy among public participants is widely evident. While positive in many respects, this state can also be attributed to the heightened attention granted technical discussion of cleanup options due to the belief that a more rational hence scientific discussion of posed options would serve to diffuse the escalating emotional climate engendered by difficult choice processes and the related problem of tradeoff avoidance.

It must be said that this is a problem common to virtually all public discussion fora. But ultimately, the most important aspect of this problem is the perennial "bogged down" state it produces. This state is best understood not only as a normal byproduct of group behavior in civic life, which it certainly is, but more importantly for public involvement, as an outcome of naïve efforts to eliminate all conflict by resorting to excessively technical discussions, and, importantly, by placing value discussions off limits. Wishing that public risk-communication venues be cleansed of value discussions does not make it so. Many risk scholars have clearly and repeatedly demonstrated that all risk debates are at their core value debates and that as such it is virtually impossible to suspend or eliminate this aspect of the debate (Kunreuther & Slovic, 1996). If this is what one tries

[12] We do not mean to suggest that these are consciously manipulative responses, but rather a normal human response to an uneasy situation. However, we do assert that (a) those facilitating public processes can become more aware of these tactics, and (b) employ decision-making strategies to help address resisted tradeoffs (discussed later in the report).

to accomplish, what invariably surfaces instead — the bogged down state — is in fact a state of "fugitive values." The deeply embedded value positions that make the decision and tradeoff processes difficult in the first place go underground but do not go away. Instead, they entangle even paralyze public discussion precisely because they infuse every point of discussion about ostensibly technical problems. These values in operation are fugitive in the sense that they move from place to place and appear in a fleeting form without ever being brought into the open where they can often be put to constructive (and ultimately more democratic) use.

5. Value Sublimation

It is telling that at the very first public meeting that Satterfield attended at Rocky Flats (in February 2001), the facilitator announced unambiguously that all discussions in the meeting were to remain focused on technical points. Value-driven discussions were isolated and excluded as "explicitly off limits."

Indeed, most participants recognized that over time, a silencing of value positions had taken place. Agreement, however, among public parties on whether this was a pejorative or successful outcome was mixed. Some CAB members regretted though tacitly accepted the fact that over time value or ethical debates had been eliminated as viable points of discussion.

> Well, in the past there's been a lot of ethical, moral, philosophical discussion. If you look back at statements by the advisory board [we made] sure that we put that up front. [But] I think DOE actually did try pretty hard to move the public away from that. A lot of what you get [now] is: 'Well we've had all of that, we've had the moral and philosophical, but now it's a science decision. And that's really dominated the past two years.

In another case, the necessity of eliminating justice or related ethical concerns from discussion was described, quite literally, as a painful state:

> I think it's especially painful for the activists who are concerned not only about technical stuff, but also about peace and justice stuff. They've got to speak in one

> dialect [a scientific one] but not the other dialect in which they are fluent [a value-based one].

Others openly complained that the silencing of value positions was insufficiently complete to the extent that they viewed stakeholder meetings as having descended into a chaos of competitive agenda-setting. “There’s a place for that [values], but when it starts to hinder the CAB process, then I think it’s not right, I think it’s counter-productive.”

5.1 Fugitive Values and Their Consequences

Regardless of whether public participants believe value sublimation tactics are a “good” or “bad” outcome, it remains the case that rendering value positions fugitive exhausts both human and fiscal resources. It can also produce unexpected consequences. First, it is exhausting for those who willingly volunteer their time as public participants only to find that the group is ‘getting nowhere’ and/or ‘spinning its wheels.’ Public discussion is often reduced to tedious and non-productive ‘talk,’ a point not missed by those involved. In the words of a CAB member:

> They think it’s a good process because there’s lot of, uh, there’s lots of, lots and lots and lots of words and lots of lots and lots of time and that’s called public participation and it is public participation and it’s just, it’s just like a sponge, it’s absorbing huge amounts of human energy

Second, under these fugitive value/tradeoff avoidant conditions, wherein distinction between ‘facts’ and ‘values’ are not made and the objectives of stakeholders are redirected into debates about the technical merits of alternative cleanup actions, public participants must and do resort to the only available option: they become entangled in a troublesome good-science/bad-science debate. And they likely attack the scientific studies that are the basis for different cleanup options and seek to hire independently conducted studies of their own. This is not to suggest that conducting independent studies or reviews are wrong. Historically, there is an undeniable legacy of deception on the part of DOE regarding the impact of their operations on public health. But if such studies are based solely on distrust they may end up re-doing already adequate studies for

reassurance when greater attention to the objectives of different groups might reveal the necessity of other equally important studies.

At those points, at Rocky Flats, where irreconcilability of scientific interpretations threatened to paralyze cleanup, new studies were conducted and new data were collected based on the premise that new and better science would resolve lingering concerns because science is naively regarded as immune from political manipulation and value-free. In actuality, advocates for ever safer and more thorough cleanup standards are pitted against those who defend a lesser standard as scientifically robust and legally defensible, to wit, both sides claim to possess the scientific upper-hand. Many recognize and even enjoy the fallacy of this argument. During an interview, one CAB member noted that everyone appears to believe that:

> the problem [of growing conflict] has a technical solution. The goal [they believe] is to use the best technical and scientific procedures and evidence possible to generate the best possible technical solution. So, it's sort of like a good science/bad science dilemma. I think there have been real powerful moments where DOE has found itself funding, to its credit, things whose outcomes it could not have predicted . . . . So, one of the things I've tried to learn is the different ways the DOE is conflicted about its own imperatives and responsibilities. . . . Science is something that has previously been used in ways that, [to me] are criminal [e.g., weapons production]. Literally [now], I've seen it get used jujitsu, aikido-like, against them.

Again, the RSAL debate provides the best case in point. Recall that initially DOE posed and defended an RSAL for plutonium of 651 picocuries per gram. The question any level tries to address is that, given particular land use scenarios, what risk exposure is safe enough? The volume of plutonium remaining in the soil is converted, depending on said use conditions, to a probabilistic risk range that meets the EPA's health-safety standards. The minimum standard is a 10^{-4} risk level (a one in ten thousand chance of developing cancer), whereas the upper level of the range sits at 10^{-6} (a one in one million chance of developing cancer). The CAB could not agree on a unified position to present to DOE. They were deeply divided and had no means for reconciling their own profound ideological and ethical differences. There were those who thought the original RSAL

numbers were, quoting a CAB staff member, “based on enough scientific process that . . . they must be safe” and those who thought “they were the worst numbers ever.”

Those who argued for the higher number believed that regulatory agencies could, by and large, be trusted and that the posed standard was safe enough. Setting an unnecessary stringent standard at Rocky Flats, they argued, wasted public funds. Critical members of the public stated that a 651 level would not ensure the safety of more vulnerable populations, namely, young people whose biological systems are still developing, people with compromised immune systems, or future generations whose potential behavior on the land cannot be predicted and thus the only defensible plan was a conservative one. But as the concerns on both parts were essentially value-based or ethical in nature — they pertained to ideas about one’s social responsibility to the public, future generations, or the “rightness” of protecting some people less well than others — they were off limits. Instead, attention focused on the technical viability of DOE’s initial results and the need to re-calculate RSAL and risk estimates.

After considerable expense ($400,000) and time, the new study recalculated RSAL numbers reflecting the complete range of end users each of which corresponded in fact to the range of CAB objectives. At the low end of the possible range, the (new) numbers were well under 40pCig-1 depending on the specifics of calculation inputs and the identity of the end user. The lowest number in the range (10 pCi g-1) was produced for the identity or end user known as “child of a resident rancher.” (Such a child might play in and eat soil and would also be fed food grown in the soil during his or her key developmental years.) But even the probable wild-life worker corresponded to a much lower number. Ultimately, at Rocky Flats, the critical public appeared to recognize that the realization of their competing value positions (however well disguised) hinged on their ability to present compelling and/or competing scientific evidence to support their positions (Nelkin, 1995).

Although the DOE consented to financing the second study, they were in the words of one CAB member, deeply “fearful [because of the cost implications] that the number would go down too far” and “horrified” when they did. In the extreme tension that followed, involved stakeholders could not manage the diversity of opinion on RSALs

within their ranks and the DOE called for a 'technical" review of the 2nd study. Thus, a new group was convened to limit the complicating role of the CAB's ethical-cum-technical division, and to, hopefully on DOE's part, challenge the plummeting and hence costly RSAL numbers with further calculations and technical review.

5.2 Group Constitution and the Anti-Democratic Consequences for Public Participation

This brings us to our final point about the consequences of tradeoff avoidance, the heightened technical discourse it inspires, and the disruptive play of fugitive values. As tradeoff avoidance and decision paralysis persisted, the role and even presence of different public discussion groups was compromised. A successive chain of 'spin-off' groups emerged. Each tended to be smaller and more focused so as to have a greater chance at reaching agreement and confining discussion to increasingly esoteric technical content. These groups would often be comprised of both DOE and Kaiser-Hill staff and only those members of the CAB or RFCLOG technically literate enough to engage in the increasingly arcane details in the first place. For instance, as noted directly above, the DOE convened the RSAL working group to review and recalculate the outputs of the second RSAL study. Secondly, and more importantly, for public participation, the CAB's role was de facto diminished. Instead, the locus of public discussion shifted to the newly convened Rocky Flats Cleanup Agreement Focus Group [or RFCA focus group]. The new group was justified as necessary because too many CAB members had neither the time nor the skill to "properly" understand the nuances of the science and the policy limitations set out in the Cleanup Agreement. Speaking specifically about the new RFCA focus group, an involved CAB member and trained Ph.D. scientist identified the group as a much anticipated opportunity to "really discuss the technical issues."

We do not mean to represent this shift as an agency slight-of-hand. Public participants appeared fully aware that a pattern of open public involvement representing the diversity of opinion (and skill) embodied in the CAB was replaced by a smaller more literate group.

> The Citizen's Advisory Board is not nearly as knowledgeable. People like myself [i.e., one of a more knowledgeable subset or core group of CAB members] are paying

> a whole less attention to the process of the advisory board than to the process of the focus group, because I think that's where the real discussion is happening . . . .. We became very very involved with the soil-action level because we were knowledgeable about this particular highly technical stuff.

Further, the focus group's aim is to resolve any differences through extensive technical debate and thereafter abide by an "announce and defend" or "teach the public the numbers" format for public discussion. To wit, focus group members will communicate their findings to the "less educated" members of the public.

> We've got a special work session planned to talk [to the CAB] about the calculations. We've done the work and we're going to bring the results of the working group back to the CAB. But what we're going to do with the CAB, is try to educate the members as to how the numbers were calculated. And then see if we can put together a recommendation [on RSALs for DOE] and hopefully we can get a recommendation fast.

The RFCA focus group was not the panacea that many hoped — a forum for rational scientifically astute discussion. Many complained that it, too, was "bogged down" and "totally dysfunctional" due to [he perceived] "people's political agenda."

Regardless of outcome, what occurred at Rocky Flats was a long and drawn-out pattern of group mutations where an ever more versed segment of the involved public along with the agency's science and policy staff, came to embody public discussion and involvement. In so doing, an important democratic principle — the need for a diverse CAB to deliberate and debate the means for achieving the best outcome for the public — was pitted against the ideal and elusive pursuit of scientific literary and hence (it was argued) reasoned debate. Invariably, at Rocky Flats, much of the legitimacy and integrity of the former democratic principle was sacrificed.

5.3 Disenchantment with Public Process

Some long-time CAB members were deeply critical of the trajectory of public involvement and were indeed aware of their diminished access to direct participation and the related lost opportunity to become more knowledgeable.

> They have all these committees that break out and then the committees give their reports. I think part of what I'd do to help with involvement and, and an understanding of the science, I would start holding committee meetings housed within our meetings on the important stuff, um, like the RSAL stuff. I would have that group [RFCA focus group] integrated into the monthly [CAB] meeting. I would stop all of this nonsense reporting [back to the group] crap that wastes our time.
>
> The whole organizational structure of the CAB, I think, is ineffective. You don't involve the citizens within the structure that they have now. There's no process for making a Board member feel welcome. There's no process of helping a Board member through the intimidation of the science. I have no idea what these committees do because I can't read the reports. The reports are all like this heavy-duty science stuff. And, I'm not going to read 20 pages of science that I don't understand and get to the end of it and go 'I have no idea what I just read.'

As of the end of the research period, it was unclear as to just where those citizens who did not or could not articulate their concerns in a fully scientific and technical idiom fit. Many simply remained silent observers until such time as they felt confident enough to speak. They noted that a "freeze settled over the group" when the implications of certain technical discussions were neither "fully understood" nor "fully explored." It would then take "someone with considerable guts" to say: "What exactly do you mean by that? At which point the other person acts offended or kind of patronizing or something."

Others still observed that tension during meetings if and when ideas were voiced by those less technically literate were common:

> You should see some of the body language that goes on around the CAB when a citizen is talking about something that we know is not right, but they don't. Instead of saying to this guy: your points have [merit]. No one responds. They just say [referring to meeting chair] 'oh, thank you very much.' That's not citizen participation, that's BS. You just bullshitted this guy. You gave him his time in the sun, you have him the microphone, he expressed a concern. You, all your body language just made fun of this guy. That is the CAB's definition of citizen participation, but it's not my definition.

Ultimately, the problem of creating a viable democratic public forum for citizens who were not able to discuss technical questions concerning cleanup was shouldered by the CAB staff. They were responsible for realizing a mandate that required that all citizens be able and welcome participants. At the same time, CAB staff were cognizant of the fact that the locus of opportunity for public participation had shifted from the CAB to RFCLOG, and in particular, the RFCA Focus Group.

> I have problems with the fact that your average citizen is not sitting at that table, it's all professional people that work for either [one of the] agencies, the city or local government ... there's only two people that I could name that participate are actually members of the general public.

5.4 Discussion — The Dynamics of Risk and Science Controversies

Previous studies of risk have shed light on how risks are perceived and how risks become amplified. A very small set of studies evaluating (critically and not) different public-participation experiments are available (Arvai, Gregory, & McDaniels, 2001; Renn, Webler, & Wiedemann, 1995; Webler, 1997). Ample anecdotal evidence and some published evidence also exists for the fact that stakeholder groups addressing radiation risks often fail to reach consensus or super-majority support (Easterling & Kunreuther, 1995). Finally, there are a number of studies that highlight the differing values held by disputing parties in risk debates (Jasanoff, 1999; Nelkin, 1992). Nelkin (1995), in particular, has found that while disputes about science as it is applied to regulatory policy are often motivated by political or moral values, the debates themselves remain preoccupied with technical questions. The value complexity of debates is matched by their strategic complexity as "moral arguments are combined with extensive use of technical expertise . . . and technical expertise becomes a resource exploited by all parties to justify competing moral and political claims" (p. 452-3).

But, as yet, there exists little systematic effort to document ethnographically the specific processes (including the complex interplay of values and knowledge) that lead to discussion paralysis across stakeholders and the resultant influence of those processes on public involvement — its shape, its characteristics, and its perceived legitimacy. In the substantive portions of this report, we have drawn on field interviews and observations at

Rocky Flats to provide a descriptive portrait of the dynamics of risk and science controversies in public-participation contexts. What follows here is a summary of this description in the form of processual model. The aim is to develop a model that can accommodate the complex details of cases like Rocky Flats for the purposes of cross-case comparisons and the development of theory.

5.5 A Structural Description of the Dynamics of Risk and Science Controversies in Public-participation Contexts

Figure 2 posits that in the Rocky Flats case two types of pressure [box 1 and 2, horizontally displayed on the left-hand side of the diagram] were exerted which produced, in turn, four primary consequences or outcomes (boxes 3 though 6, vertically displayed on the right side of the diagram).

Box 1 — Decision Parameters. The first two boxes, "pressures," denotes that decision parameters are necessarily imposed on stakeholders but that the actions under discussion involve a high degree of uncertainty. Federally, there exist numerous epistemological uncertainties about the health effects of and hence necessary standards for radiation exposure. At Rocky Flats, Kaiser-Hill is among the first engineering contractor to take on the task of cleaning up one of the many nuclear arsenal production sites within the DOE complex. They invested considerable time and resources preparing and negotiating a contract with the federal government and likely budgeted for numerous contingency or worst case scenarios. It is telling that the first cost estimate for cleanup, put forth by EG&G in 1990, was 36 billion dollars; the estimated cleanup deadline was 70 years or a 2060 closure date. This earlier estimate is nearly five times Kaiser-Hill's 7.3 billion dollar budget and schedule. The gross discrepancy in estimates likely indicates that it is difficult at best to know with even a modicum of precision what cleanup will involve, what technologies will be used or developed to conduct the necessary decontamination and decommissioning of the site, how long it will take, and how much it will cost. (During the period of study, stakeholders widely acknowledge that Kaiser-Hill was over-budget and behind schedule as did the federal government, (U. S. General Accounting Office, 2001) These uncertainties placed the contractor and the client (DOE) in a position of heightened and chronic vigilance with regard to costs and schedule. This

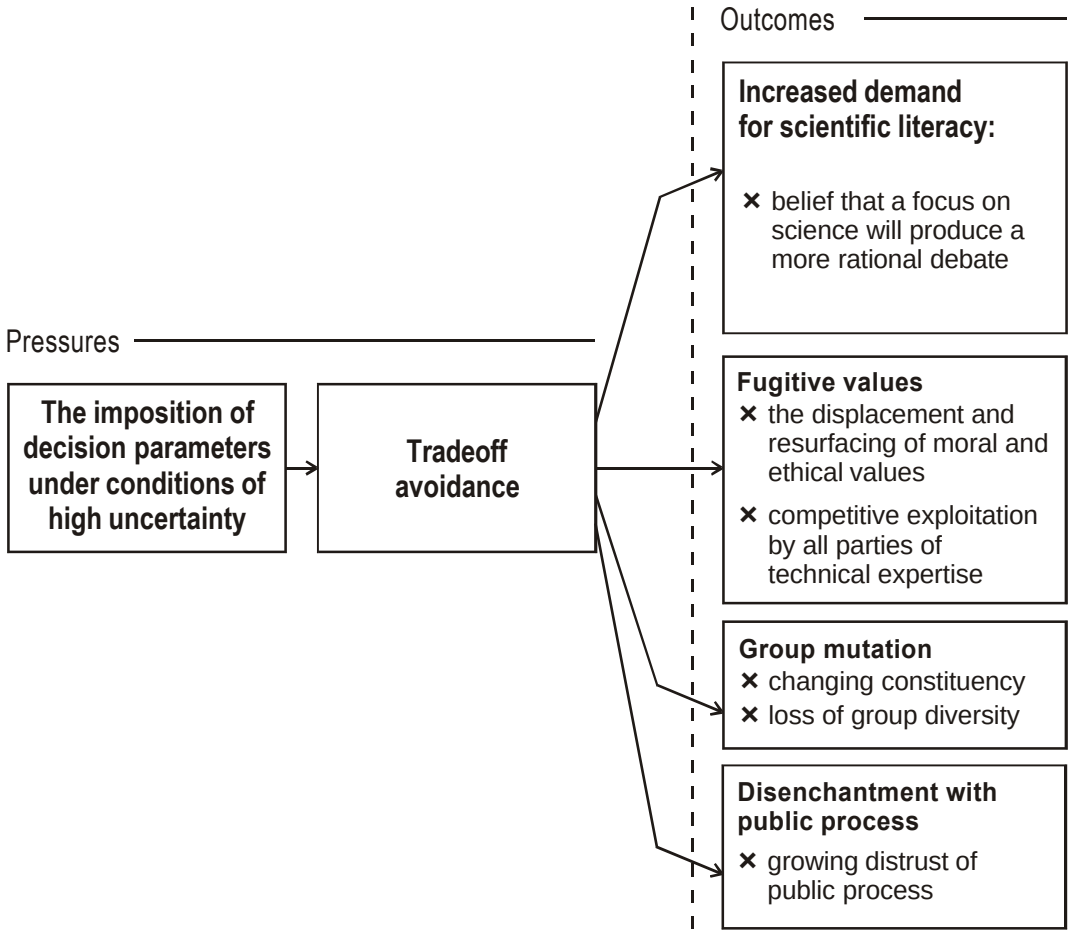

Figure 2. The dynamics of risk and science controversies in public participation contexts.

vigilance came into direct conflict with efforts to set RSALs because the final RSAL would determine how to spend a significant portion of the overall budget (and because there was concern that a low RSAL at Rocky Flats would set a dangerous cost-precedent at future sites in the complex).

Box 2 — Tradeoff Avoidance. Cost limitations and temporal deadlines are a given in any project of this kind. Moreover, those most responsible for site decisions know only too well that tradeoffs must be made in order achieve the end goal of cleanup. But it is invariably difficult for regulators to voice clearly and consistently the necessity of tradeoffs and to address them head-on with full recognition of what making such tradeoffs involves. This is due in part to agency fears that they will come across as assigning a monetary value to human life. More broadly, there are many psychologically compelling reasons why such tradeoffs are regarded as 'taboo.' These problems are augmented by the fact that regulators fail to recognize that it is virtually impossible to make tradeoffs without clearly addressing the objectives or values that underpin why one option is selected over and above other competing options.

These two phenomena — Box 1 and 2: decision parameters under uncertainty and tradeoff avoidance — converge to exert extraordinary pressure on the capacity for a diverse body such as Rocky Flat's CAB, RFCLOG, and the many linked stakeholders to operate. Several outcomes can thus emerge.

Box 3 — Increased Demand for Scientific Literacy. The increased pressure and tension exerted by a climate of tradeoff avoidance and decision making under uncertainty was met by elevating expectations for scientific literacy under the guise that the more problematic value considerations could be cleansed from the discussion and a more rational debate across stakeholders would thus prevail.

Box 4 — Fugitive Values. When value considerations are increasingly sublimated, value differences across stakeholders do not go away, rather they become "fugitive" forces in the discussion. Points about value are forced to masquerade as technical points encouraging more than is necessary the competitive exploitation by all parties of technical expertise. At Rocky Flats this was most clearly demonstrated during the protracted debate about RSALs.

Boxes 5 and 6 — Group Mutation and Disenchantment with Public Process. As the interplay of tradeoff avoidance, fugitive values, and a "science only" discussion persists, the role of public discussion groups is compromised. New groups emerge, each more highly specialized and more highly focused on technical points of discussion. The assumption is that these new modified specialist groups will resolve their differences and having done so, will 'educate' or convince the larger involved group accordingly. In so doing, the very principle of a diverse citizen board and democratic public involvement is undermined and widespread disenchantment ensues.

6. Conclusion

Understanding the nature of risk communication and public-participation programs is a difficult task. However, little is known (beyond the anecdotal or the abstract) about just how and why efforts to involve an interested public in specific discussions about risk management and remediation programs suffer periods of protracted paralysis, even fail, or why they are forced to deviate from their initial democratic, multi-stakeholder (and intrinsically democratic) good intentions.

Risk scholars have argued vehemently that risk debates are value debates and that as such involving the public in risk-management decision processes is essential (National Research Council, 1996). Small group discussions (Gregory, 2000), citizen advisory boards (Vari, 1995), citizen juries (Crosby, 1995), and public opinion surveys have flourished of late in an effort to fulfill this widespread call for public involvement. Less academically, there are now any number of practitioners who consider themselves experts at facilitating public involvement. While this general trend toward public involvement should be applauded for its fundamentally democratic spirit, it is not the case that *any* public involvement is *good* involvement. Increasingly, federal agencies are embracing stakeholder groups with little or no knowledge of how to structure that involvement so it is productive and not destructive. Indeed, among those who follow public-involvement efforts, there is increasing talk of a "backlash" against public involvement because so many efforts exhaust all social and fiscal resources and yet fail to produce a decision outcome that is supported by the vast majority or ideally all of the those involved stakeholders.

Without better diagnostic evidence, there is little basis for improving the operation of citizen advisory boards, and their many variations, or for instructing federal agencies on the importance of good quality, well-structured public involvement. More importantly, the Rocky Flats case demonstrates clearly that any public participation effort that (a) fails to properly and systematically address the fundamental importance of making tradeoffs and decision parameters clear *and* (b) openly debate and analyze the value positions with which those tradeoffs are associated, will likely lead to a breakdown in public involvement. Further, an insistence on greater technical literacy has some benefits but if that 'literacy' is the product of naï ve efforts to minimize conflict, then it will only serve to obfuscate the more fundamental ethical conflict at play and eventually erode the possibility of meaningful involvement across a demographically and educationally diverse public.

Acknowledgements

This research was supported by funding from the U. S. Department of Energy, Low Dose Radiation Research Program, Office of Biological and Environmental Research, Office of Science, under Cooperative Agreement Number DE-FC07-99ER63879 with Decision Science Research Institute. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the U. S. Department of Energy.

References

Ackland, L. (1999). Making a real killing: Rocky Flats and the nuclear west. Albuquerque: University of New Mexico Press.

Arvai, J. L., Gregory, R., & McDaniels, T. L. (2001). Testing a structured decision approach: Value focused thinking for deliberative risk communication. Risk Analysis, 21(6), 1065-1076.

Baron, J., & Leshner, S. (2000). How serious are expressions of protected values? *Journal of Experimental Psychology, 6,* 183-194.

Baron, J., & Spranca, M. (1997). Protected values. Organizational Behavior and Human Decision Processes, 70, 1-16.

Crosby, N. (1995). Citizen juries: One solution for difficult environmental questions. In O. Renn & T. Webler & P. Wiedemann (Eds.), Fairness and competence in citizen participation. Boston: Lower Academic.

Easterling, D., & Kunreuther, H. (1995). The dilemma of siting a high-level nuclear waste repository. Boston: Kluwer Academic.

Erikson, K. T. (1994). A new species of trouble: The human experience of modern disasters. New York: Norton.

Fischhoff, B. (1995). Risk perception and communication unplugged: Twenty years of process. Risk Analysis, 15(2), 137-145.

Fiske, A. P., & Tetlock, P. E. (1997). Taboo trade-offs: Reactions to transactions that transgress spheres of justice. Political Psychology, 18, 255-297.

Gregory, R. (2000). Using stakeholder values to make smarter environmental decisions. Environment, 42(5), 34-44.

Gregory, R. (in press). Incorporating value tradeoffs into community-based environmental risk decisions. Environmental Values.

Jasanoff, S. (1999). The songlines of risk. Environmental Risk, 8(2), 127-134.

Keeney, R. L. (1996). The role of values in risk management. The Annals of the American Academy of Political and Social Science, 545, 126-134.

Kraus, N., Malmfors, T., & Slovic, P. (1992). Intuitive toxicology: Expert and lay judgments of chemical risks. Risk Analysis, 12, 215-232.

Krimsky, S., & Golding, D. (1992). Social theories of risk. Westport, CT: Praeger-Greenwood.

Kunreuther, H., & Slovic, P. (1996). Science, values, and risk. The Annals of the American Academy of Political and Social Science [special issue on risk assessment and risk management], 545, 116-125.

MacGregor, D. G. (2002). Ionizing radiation: A tutorial on sources and exposures (Version 2.0, Report No. 02-02). Eugene, OR: Decision Research. Retrieved July 31, 2002, from the Decision Research Web site: http://www.decisionresearch.org/Projects/Low_Dose/research_reports.html.

Martland, H. S., Conlon, P., & Knef, J. P. (1925). Some unrecognized dangers in the use and handling of radioactive substances with especial reference to the storage of insoluble products of radium and mesothorium in the reticula-endothelial system. Journal of the American Medical Association, 85, 1769-1775.

Morgan, G., Fischhoff, B., Bostrom, A., & Atman, C. (2002). Risk communication: A mental models approach: Cambridge University Press.

National Academy of Sciences. Committee on the Biological Effects of Ionizing Radiation. (1990). Health effects of exposure to low levels of ionizing radiation: BEIR V. Washington, DC: National Academy Press. Retrieved July 31, 2002 from the National Academy Press Web site: http://www.nap.edu/books/0309039959/html/.

National Research Council. Committee on Risk Characterization. (1996). Understanding risk: Informing decisions in a democratic society. Washington, DC: National Academy Press.

Nelkin, D. (1992). Controversies: Politics of technical decisions (3rd ed.). Newbury Park, CA: Sage.

Nelkin, D. (1995). Forms of intrusion: Comparing resistance to information technology and biotechnology in the USA. In M. Bauer (Ed.), Resistance to new technology (pp. 379-390). New York: Cambridge University Press.

Powell, D. A., & Leiss, W. (1997). Mad cows and mother's milk: The perils of poor risk communication. Montreal, Quebec: McGill-Queen's University Press.

Renn, O., Webler, T., & Wiedemann, P. (1995). Fairness and competence in citizen participation. Dordrecht, The Netherlands: Kluwer.

Slovic, P. (1987). Perception of risk. Science, 236, 280-285.

Slovic, P. (1992). Perception of risk: Reflections on the psychometric paradigm. In S. Krimsky & D. Golding (Eds.), Social theories of risk (pp. 117-152). New York: Praeger.

Slovic, P. (2000). The perception of risk. London: Earthscan.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1979). Rating the risks. Environment, 21(3), 14-20, 36-39.

U. S. General Accounting Office. (2001). Nuclear cleanup: Progress made at Rocky Flats, but closure by 2006 is unlikely, and costs may increase (Report No. GAO-01-284). Washington, DC: U. S. Government Printing Office.

Vari, A. (1995). Citizens' advisory committee as a model for public participation: Evaluating models for environmental discourse. In O. Renn & T. Webler & P. Wiedemann (Eds.), Fairness and competence in citizen participation. Boston: Kluwer Academic.

Walker, S. (2002). Permissible dose. Berkeley: University of California Press.

Webler, T. (1997). Organizing public participation: A critical review of three handbook. Human Ecology Review, 3, 245-254.